$\frac{1}{4}\lambda$ and $\frac{1}{2}\lambda$, the cotidal hour above the nodal line should, by lemma 8, be III. These requirements are in general accord with observation.

The South Indian system consists of a simple area extending from the south coast of Australia southwesterly $\frac{1}{2}\lambda$ to where it is supported by the Antartic Continent; thence northwesterly $\frac{1}{2}\lambda$ to Madagascar and South Africa. The cotidal hour, at either end, should be III. Moreover the nodal line falling near Cape Leeuwin prevents there being any sensible semidiurnal tide at Freemantle on the western coast. These statements accord well with observation. It remains to be observed whether or not the cotidal hour where this area rests against the Antartic Continent is IX.

The South Australian system consists of a simple area extending from the Antartic Continent, a distance of about $\frac{1}{2}\lambda$ (solar) to the south coast of Australia. The solar cotidal hour for the north end should be VI and for the south end XII. Observations at Port Adelaide show that the solar wave is there large, and that the age of the tide is considerable as this theory would imply. But there is need of more information about the tides along this coast of Australia.

In comparing the above schemes with the results of observation, particular attention should be paid to the cotidal lines shown in Berghaus' Physikalischer Atlas (1892) and to the results of harmonic analyses, rather than to the older cotidal charts.

NOTES BY THE EDITOR.

THE MEASUREMENT OF RADIANT HEAT.

The Editor frequently receives suggestions or inquiries relative to methods of measuring the heat received by the earth from the sun. This is undoubtedly the most important and fundamental problem of meteorology; the solar heat is to the atmosphere what the fire is to the steam engine, and the time will come when mathematicians and physicists will be able to give a full account of the work done by this source of energy. Perhaps the first apparatus that gave any idea of the amount of heat received from the sun was that invented by Sir John Herschel and called an actinometer. This was improved upon by Pouillet, whose pyrheliometer has long been a standard method of measuring solar heat. During recent years different forms of improved apparatus have been developed by Crova, Violle, Maurer, Chwolson, and, perhaps best of all, by Knut Angström, of Upsala. In all of these it is clearly recognized that the intensity of radiation, namely, the quantity of heat received per square unit per minute of time, is not indicated by any of the numerous forms of apparatus in which a thermometer exposed to the sunshine becomes heated to some high but stationary temperature. This so-called static method of measurement must be replaced by the so-called dynamic method in which the thermometer or its equivalent is exposed to the sunshine and then completely shaded from it alternately several times, so that we may measure the rate of heating under the influence of all sources of heat, including the sunshine, and again the rate under the influence of all sources except sunshine.

As Angström's apparatus is to be recommended, we submit the following description for the guidance of our correspondents.

In Angström's electrical compensation pyrheliometer, as described by him in 1893, and again in 1899 (Wiedemann Annalen, vol. 67, page 633–648) we have, after continued use for several years, an instrument adapted to a wide range of work. It consists of two thin exactly similar and equivalent metal strips, each blackened on one side. One of these is exposedto the radiation that is to be measured, the second is thoroughly protected from this and other obnoxious radiations but is warmed by the passage of an electrical current. If the electrical current is so regulated that both metal strips are equally warmed, then the quantity of heat given to the first by radiation is equal to that produced in the second by the electric current; this equality in the temperatures is determined by means of thermo-electric elements attached to the back of each strip. If q is the energy of radiation per second, per square centimeter, expressed in gram calories, b the breadth of the metal strip, a the power of absorption per unit length of the strip, on its lampblack side, r the resistance of the unit length of the strip to the electric current, i the intensity of the electric compensation current, then we have the relation $b\ a\ q = ri^2 / 4.18$, whence we obtain the desired energy of radiation in gram calories $q = ri^2/4.18\ b\ a$ in gram calories per second per square centimeter, or $q = 60\ ri^2/4.18\ ba$ in gram calories per minute per square centimeter. By this method we avoid any correction for radiation, convection, or reduction, since these sources of error are assumed to be the same for both strips on account of their equality as to size and temperature. We also need to determine the constants r b and a only once; each determination of the radiation needs only one observation of the intensity of the current, i, in order to obtain the radiation in absolute measure. As r varies slightly with temperature this variation must also enter into the calculation. The two similar metal strips must, of course, be prepared with the greatest care. The blackening of one side of each strip gives to the edges a slight roughness so that an error of 0.01 mm. in the width can scarcely be avoided; this introduces an uncertainty of one-half of one per cent in the results by the apparatus used by Angström. The thermo-electric element is at the back of the metal strips. In order to secure symmetry in the radiation from the rear surface the backs of the strips are covered with black varnish. The fronts are covered with lampblack laid over a thin deposit of zink and platinum chloride. The resistance of the strips to electric currents is determined by the use of Lippman's capillary electrometer. The most important and difficult constant to determine is the power of the lampblack side of the strip to absorb radiant heat. Angström's investigations show: (*a*) That the absorptive power of platinum black is only slightly increased by covering it with lampblack, but is more uniform than lampblack for different wave lengths. (*b*) The surface that has this double covering has an absorptive power that is slightly selective in that it increases with the increase of wave length. (*c*) Its average absorptive power for solar radiation increases from 98.3 to 98.8 per cent with the increase in the thickness of the layer of lampblack. (*d*) If we assume the absorptive power of such surfaces to be the same for all wave lengths and equal to 98.5 per cent, then the error thereby introduced into the determination of the intensity of the radiation would not exceed one-half per cent. It is best to use two different galvanometers for the temperature equality and for the current intensity, respectively.

Laboratory experiments show that different instruments give results that agree closely, and do not change with time, and that those with the compensation pyrheliometer are accurate to within one-half of one per cent. In 1895 and 1896 Professor Angström determined the absolute intensity of the solar radiation by observations with a special light and portable apparatus on the summit of the Peak of Teneriffe. The full report of this important work has not been published, but from the preliminary notice it appears that his apparatus has given an important addition to our knowledge of the solar radiation and of the atmospheric absorption at that place. This portable compensation pyrheliometer, with rheostat, small galvanometer, electro-dynamometer, and Leclanche cell, packed in a box 16 inches high, 10 inches wide, and 5 inches deep, weighs, with its tripod, 15 pounds, and is so arranged that it can be set up for use in a very few minutes. Angström's apparatus is equally applicable to the measurement of the radiation from very feeble sources of heat, such as a lamp or a warm block of stone or metal, and is peculiarly valuable as a means of determining the constants of the bolometer or thermopile.

THE USE OF THE DIVINING ROD IN THE SEARCH FOR WATER.

According to the Scientific American for April 7, 1900, a commission has been appointed in France to study all apparatus and methods employed by sorcerers, water seers, and wizards, who use the divining rod, mineral rod, exploring pendulums, hydroscopic compasses, and the other instruments which go by a host of other fanciful names. The French engineer, M. Borthier de Rollière, is the president of the commission. He will procure divining rods of all kinds, including books, reviews, journals, reports of experiments, together with the names and addresses of the inventors of the alleged devices. All the facts and documents may be sent to M. de Rollière, care of Cosmos, 8 Rue François Premier, Paris, France. It is to be hoped that the findings of this commission will, once for all, settle the question of the divining rod, not only for the discovery of water, but also minerals. In England, particularly, the water diviner plies his lucrative profession without legal interference, and strange to say, his dupes are often town authorities. The whole business is akin to that of the fortune teller, the spiritualist, or any other charlatan, and it is strange that the exponents of such systems are allowed to pursue their avocations undisturbed by fear of prosecution. At present the victims are the only ones punished.

TIDES IN THE OCEAN AND THE ATMOSPHERE.

The Editor has from time to time received requests for a satisfactory popular explanation of the manner in which the attractions of the sun and moon produce tides in the ocean, and why it is that similar gravitational tides in the earth's atmosphere are not observed. Such an explanation has been in manuscript for several years, undergoing the emendations of critics who are familiar with the subject, and will, we hope, when published, satisfy the desires of our correspondents.

Of late years special attention has been given by eminent meteorologists and physicists to the proper explanation of the periodic variations in atmospheric or barometric pressure, known as the diurnal, simidiurnal, and terdiurnal periods. It seems to be agreed that these do not owe their origin to any action of solar or lunar gravitation, but that they may be the result of solar heat which expands the lower atmosphere and maintains a so-called diurnal wave of temperature in the atmosphere which gives rise to a wave of elastic pressure. Such a pressure wave would run around the earth in twelve hours, if the average temperature of the air were —5° C., whereas the temperature wave goes round once in twenty-four hours. Therefore, a stationary free pressure wave would be maintained by the forced temperature wave and produce both diurnal and semidurnal barometric oscillations. If the temperature of the atmosphere were higher than at present the rate of wave progress, for the free wave, would be less than now, and there might be a temperature at which the diurnal and semidiurnal oscillations would be much greater than at present.

When we study the geographical distribution of the barometric oscillations we find them varying with latitude and longitude, and especially with the continental or oceanic position of the stations. This is plausibly due to the fact that wave progress varies with temperature and pressure, but especially with the depth of the oscillating liquid. In this respect there may be much analogy between the motions of limited portions of the atmosphere and limited portions of the ocean. On a preceding page we publish a memoir by Mr. Rollin A. Harris, of the Tidal Division of the United States Coast and Geodetic Survey, in which he shows how local oscillations of restricted portions of the ocean, similar to the seiches of the Swiss lakes, can affect the general oceanic tidal wave and produce the actual tides that are of importance to navigators, while the principal tide in mid-ocean is comparatively small. The memoir of Mr. Harris is worthy of consideration by those engaged in studying periodic barometric oscillations.

SOLAR SPOTS AND TERRESTRIAL PHENOMENA.

According to an article by Dr. J. Halm, published in Nature March 8, 1900, it may be possible that the sun spots are an index to the existence of what may be called cosmic forces that have to do, not only with the magnetic storms and the aurora on the earth, but with minute disturbances in the annual motion of the earth around the sun. As is well known the solar spots had a minimum near the middle of the eighteenth century. Since that time the eleven-year periods have been well marked, but the intervals of minima and maxima have varied considerably; there was a high maximum in 1783, a low minimum in 1816, a high maximum in 1838, a moderate minimum in 1861, a small maximum, 1873, and a low minimum in 1888. By comparing the irregular changes in the obliquity of the earth's orbit with the curve of sun spots Dr. Halm finds three maxima and minima, viz, those of 1780, 1815, and 1840, and perhaps other smaller ones, clearly recognizable in both curves, and he states that after taking account of this new disturbing force, due to solar spot activity, the observed values of the mean obliquity are brought into entire agreement with the deductions of planetary theory based on Newton's law of gravitation. He adds that exactly the same peculiarities appear in the variations of all the other elements of the motion of the earth; they all show well-marked periodic fluctuations closely agreeing with those of the great spot period. This connection suggests to him that this solar force, which thus seems to modify the law of universal gravitation and the action of the sun upon the ellipsoidal excess of the earth's mass, may also affect the latitudes of places on the earth, that is to say, the position of the earth's axis within the earth. The recent investigations of Chandler into the variations of latitude when compared by Dr. Halm with the sun spot curve show that—

> The radius of the circle described by the pole of instantaneous rotation is greatest at times of sun spot minima and smallest at times of maxima. This correspondence holds true for the whole interval of sixty years now covered by Dr. Chandler's investigations * * * the latitude phenomena lagged behind the spot curve by about 1.5 years. * * * Sir Norman Lockyer discovered that a similar lag can be traced in the curves representing the changes in the lines widened in sun spot spectra during a spot cycle; the maxima and minima of the spectroscopic curves, so far as the observations go, show a perfect synchronism with those of the curve of latitude variation.

Dr. Halm says:

> We are, it seems to me, fairly warranted in assuming the force acting in such a peculiar way on the motion of the terrestrial pole to be